INTRODUCTION TO SCAPULAR FRACTURES

The scapula is an integral part of the connection between the upper extremity and the axial skeleton. This highly mobile, thin sheet of bone articulates in three different joints: with the humerus in the glenohumeral joint, with the clavicle in the acromioclavicular joint, and with the thorax in the scapulothoracic joint. To accomplish a full range of shoulder motion, a smooth coordination is required of motion in all three articulations. Therefore, a complex interaction of several muscles that envelope the scapula is necessary.146 Besides its assistance in the movements of the arm in the shoulder joint, the scapula has two other functions. It is a mobile platform for the humeral head and upper extremity to work against, and it serves as a point of attachment for muscles, tendons, and ligaments.62 No less than 18 different muscles insert on or originate from the scapula allowing six basic movements of the shoulder blade over the posterior chest wall: elevation, depression, upward rotation, downward rotation, protraction, and retraction.63

Scapular fractures are generally the result of a high-energy trauma with a high incidence of significant associated (local and remote) injuries.3,67,79,115,116,169,184,191 These associated injuries are often major, multiple, and sometimes life-threatening, therefore needing priority in treatment. The relative infrequency (prevalence 1 %) and “benign characteristics” of a scapular fracture probably explain the limited attention in the literature.78 Historically, scapular fractures have been treated by closed means. One of the earliest descriptions of treating scapular fractures was published in 1805 in Desault’s treatise on fractures. Since then, it has been suggested in the literature that over 90% of scapular fractures are non- or minimally displaced and do well with conservative treatment.79,115,184 This observation, however, has been based on the treatment of scapular fractures in general and its relevance is therefore very limited. A more differentiated approach is necessary as good results are not guaranteed with exclusively conservative treatment.8 Recent literature is more focussed on the results of conservative273,115 or operative treatment41,42,61,66,74,84,98,99,112,132,133,156 with regard to specific fracture types. This contrasts with publications before the 1990s which were particularly focussed on the trauma mechanism and associated injuries.115,116,169,184 Specific types of scapular fractures are severe injuries that may result in significant shoulder dysfunction. There are a few reports on poor
pragosis after conservative treatment of displaced glenoid, scapular neck, coracoid, and acromion fractures.\textsuperscript{1,77,127} Along with technical refinement of diagnostic tools, more attention is currently paid to these fracture types as demonstrated by the rising number of publications on this subject.

PRINCIPLES OF MANAGEMENT

Mechanisms of Injury

Scapular fractures are caused by different mechanisms, of which blunt trauma is probably the most common.\textsuperscript{1,3,8,115,116,169} This direct force may cause fractures in all anatomic areas of the scapula. Other mechanisms are indirect injuries: (1) traction by muscles or ligaments may induce avulsion fractures of the acromion or coracoid, which in rare cases are caused by a seizure or an electrical shock\textsuperscript{110,166}, and (2) impaction of the humeral head into the glenoid fossa which may induce glenoid and some scapular neck fractures.

As in general with high-energy trauma, traffic accidents are the main cause of scapular fractures (occupants of motor vehicles in about 50% of cases\textsuperscript{1,8,115} and pedestrians in 20%\textsuperscript{3,115}). Other causes are motorcycle accidents, fall from heights, crush injuries, or sporting activities (horseback riding, skiing, and contact sports).

Associated Injuries

Usually, high energy is required to fracture a scapula, hence scapular fractures are commonly associated with concomitant injuries. Research shows that 61%–98% of scapula fractures have associated injuries.\textsuperscript{1,3,17,79,97,115,116,165,169} These associated injuries may be multiple and may need priority in treatment. As a result, diagnosis and treatment of scapular injuries may be delayed or suboptimal.

A wide variety of regional and remote injuries have been reported which may be life-threatening, such as pneumothorax (9%–38%),\textsuperscript{3,45,118,169} pulmonary contusion (8%–54%),\textsuperscript{45,115,169} arterial injury (11%),\textsuperscript{45,169} closed head injuries (20%–42%),\textsuperscript{70,115} and splenic or liver lacerations 3%–5%.\textsuperscript{118} These associated injuries may be multiple and may need priority in treatment. As a result, diagnosis and treatment of scapular injuries may be delayed or suboptimal.

In a recent review article on the operative treatment of scapular fractures, Lantry\textsuperscript{97} analyzed the associated injuries of 160 cases in 11 different studies. Rib fractures were the most common associated injury, followed by head and chest injuries. Fractures in remote anatomic areas were found in nearly 20% of patients. To determine the significance of scapular fractures in blunt trauma, Stephens\textsuperscript{161} compared two matched groups of patients with and without scapular fractures. Except for a significantly higher incidence of thoracic injuries in the group with scapular fractures, he found no difference in mortality or incidence of neurovascular injuries. Vesley\textsuperscript{179} reported in 2003 that patients with scapula fractures have more severe underlying chest injuries and overall injury severity scores (ISS). However, these findings, which were confirmed by other authors,\textsuperscript{161,183} did not correlate with a higher rate of intensive therapy unit admission, length of hospital stay, or mortality. There is no clear correlation between the number and severity of associated injuries and the type of scapular fracture. Nevertheless, Tadros\textsuperscript{165} found in a prospective study that the ISS and abbreviated injury score for chest injuries are higher and posterior structure injuries are more frequent in patients with fractures involving multiple scapular regions.

In summary, scapular fractures should alert the surgeon to the presence of other, sometimes very severe injuries. Severe chest injury should also raise suspicion of a possible scapular fracture.\textsuperscript{108}

History and Physical Examination

A patient with a scapular fracture typically presents with the arm adducted along the body and will protect the injured shoulder from all movements.

Physical examination may reveal swelling, ecchymosis, crepitus, and local tenderness. The ecchymosis is in general less than expected probably because the scapula is protected by a thick layer of soft tissue. Active range of motion is restricted in all directions. Abduction in particular is very painful.

Nevisier\textsuperscript{126} described in 1956 that the rotator cuff function is weak and very painful secondary to inhibition from intramuscular hemorrhage. This has been described as a “pseudorupture” of the rotator cuff and usually resolves within a few weeks. When a scapular fracture is diagnosed, it is important to perform a careful neurovascular examination to rule out arterial injury and/or brachial plexopathy.

Imaging and Other Diagnostic Studies

After initial assessment, according to Advanced Trauma Life Support (ATLS) principles, specific radiographic evaluation of the injured shoulder is indicated as soon as the patient is in a stable condition. Associated injuries requiring urgent treatment may force the treating surgeon, particularly in polytrauma patients, to evaluate the chest only by a routine supine chest radiograph. This is the earliest opportunity to identify a scapular fracture. Harris\textsuperscript{68} pointed out in a retrospective analysis of 100 patients with major blunt chest trauma that the scapular fracture was diagnosed on the initial chest radiograph in only 57 of 100 patients and, although present, was not recognized in 43%. Particularly extensive associated chest injuries may overshadow the scapula with a delay in diagnosis as a result.\textsuperscript{164}

Scapular fractures are notoriously difficult to visualize radiographically. Except for the chest radiograph, a true anteroposterior (AP) view, perpendicular to the plane of the scapula, a lateral, and an axillary view are recommended. A true axillary projection of the glenohumeral joint and scapula is ideally performed with the arm in 70 to 90 degrees of abduction, which might be very painful for the patient in the acute situation. Alternatives for this view are the Velpeau axillary lateral view\textsuperscript{12} (see Fig. 39-15) or the trauma axillary lateral view\textsuperscript{170} which can be taken while the patient is supine. In case of a complex shoulder injury with a double disruption of the superior shoulder suspensory complex (SSSC) (Fig. 39-21), a weight-bearing AP projection of the shoulder is recommended by Goss.\textsuperscript{60}

Most scapular fractures will be diagnosed by the three-view scapula trauma series, but special views may be necessary for selected fracture types. The Stryker notch view is useful for coracoid fractures (see Fig. 39-20) while the apical oblique view\textsuperscript{48} and the West Point lateral view\textsuperscript{147} are useful for glenoid rim fractures. In cases of scapular fractures with multiple frac-
ture lines and particularly significant displacement, a computed tomography (CT) scan is recommended, although the additional value is not clear in every fracture type. It is however useful to assess the size, location, and degree of displacement of fragments in coracoid, acromion, and glenoid fractures. In glenoid fractures, it is also helpful to evaluate the position of the humeral head in relation to the glenoid fossa or fracture fragment (Fig. 37-2). Finally, a three-dimensional CT scan can be very helpful in understanding complex fracture patterns and in preoperative planning.

### Diagnosis and Classification

Scapular fractures are generally classified by anatomic area (body and spine, glenoid cavity, glenoid [scapular] neck, acromion, and coracoid).

Fractures of the body and spine are the most common (approximately 50%), followed by the scapular neck (approximately 25%), glenoid cavity (approximately 10%), acromion (approximately 8%), and coracoid process (approximately 7%). There are several other classification systems reported in the literature. Zdravkovic and Damholt divided scapular fractures into three types: type 1, fractures of the body; type 2, fractures of the apophysis (including acromion and coracoid); and type 3, fractures of the superior lateral angle, including the glenoid neck and glenoid. Zdravkovic and Damholt considered type 3 fractures, which represented only 6% of their series to be the most difficult to treat.

Thompson and colleagues presented a classification system which also divided scapular fractures into three different classes:
Class 1: acromion, coracoid, and minor fractures of the body
Class 2: glenoid and scapular neck fractures
Class 3: major scapular body fractures

In their opinion, classes 2 and 3 were much more likely to have associated injuries.

Wilber and Evans\textsuperscript{184} divided scapular fractures into two groups. Group 1 included patients with fractures of the scapular body, scapular neck, and spine; group 2 included patients with fractures of the acromion, coracoid process, and glenoid. They reported poor functional outcome caused by loss of glenohumeral motion and residual pain in patients of group 2.

Finally, the Orthopaedic Trauma Association’s (OTA) classification, which was originally published in 1996, has been revised for scapular fractures.\textsuperscript{107} In this new format, the differences between the OTA and AO classification have now been eliminated by a unified alpha-numeric code (Fig. 37-3).
**Glenoid Fractures**

The most commonly used classification scheme concerning glenoid fractures is the one devised by Ideberg et al., who described five different fracture types. Goss modified this system by subdividing type 5 and introducing type 6, a stellate glenoid fracture with extensive intra-articular comminution (Fig. 37-4).

The diagnosis of glenoid neck fractures can be made with the standard three-view trauma series. The axillary radiograph combined with CT scanning is used to demonstrate any subluxation or displacement.

**Scapular Neck Fractures**

Scapular neck fractures are extra-articular fractures by definition. Although three fracture patterns have been described as scapular neck fractures, only two run through the scapular neck (Fig. 37-5). One fracture pattern runs lateral from the origin of the coracoid to the lateral border of the scapula (anatomic neck), and the other runs medial from the coracoid to the lateral border of the scapula. According to the OTA, both are classified as type 14-C1 (see Fig. 37-3).

Diagnosis of a scapular neck fracture is reliably made by plain films, in contrast with assessment of the amount of fracture displacement and angulation. A common method to determine angulation deformity and shortening, as described by Bestard, is on an AP radiograph of the scapula (Fig. 37-6). Three-dimensional CT reconstruction images may be of more benefit in assessment of displacement and angulation, in contrast with the images of a conventional CT scan.

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**FIGURE 37-4** Classification of fractures of the glenoid cavity: type Ia, anterior rim fracture; type Ib, posterior rim fracture; type II, fracture line through the glenoid fossa exiting at the lateral scapular border; type III, fracture line through the glenoid fossa exiting at the superior scapular border; type IV, fracture line through the glenoid fossa exiting at the medial scapular border; type Va, combination of types II and IV; type Vb, combination of types III and IV; type Vc, combination of types II, III, and IV; type VI, comminuted fracture. (Goss TP. Scapular fractures and dislocations: diagnosis and treatment. J Am Acad Orthop Surg 1995;3(1):22–33, with permission.)
Acromion Fractures
Kuhn\textsuperscript{90} has proposed a subclassification of acromion fractures, which are classified by the OTA as type 14-A1 fractures, to help determine the need for operative intervention (see Fig. 37-4). According to the classification of Kuhn, type 1 are nondisplaced fractures, type 2 displaced fractures without reduction of the subacromial space, and type 3 displaced fractures with reduction of the subacromial space (Fig. 37-7)\textsuperscript{90}

The diagnosis is radiographic. A three-view trauma series, including an AP view, a lateral view, and an axillary view of the scapula, will detect most acromial fractures. Caution should be used to differentiate an acromial fracture from an os acromiale. An axillary radiograph of the contralateral shoulder may be helpful, because an os acromiale is bilateral in approximately 45\% to 62\% of the cases\textsuperscript{38,101}. Occasionally, a CT scan is necessary to define the configuration of the fracture precisely (Fig. 37-8C).

Coracoid Fractures
Ogawa\textsuperscript{133} who simplified the classification scheme of Eyres\textsuperscript{42} classified coracoid fractures into two different types. Type 1 is situated proximal to the coracoclavicular ligament attachment and type 2 distal to these ligaments (Fig. 37-9). Ogawa\textsuperscript{133} suggested that a type 1 fracture may disturb the scapulothoracic connection (see Fig. 37-1).

The complex anatomy of the scapula makes defining the fracture type difficult. The coracoid process is not easily visualised on a radiograph. Apart from the usual three-view trauma series, an AP tilt view (35–60 degrees),\textsuperscript{60} a Stryker notch view,\textsuperscript{145} and a Goldberg posterior oblique 20-degree cephalic tilt view\textsuperscript{53} may be helpful. A CT scan with three-dimensional reconstruction images will give more insight into the fracture pattern.

Scapulothoracic Dissociation
Damschen et al.\textsuperscript{29} proposed a classification system for scapulothoracic dissociation in 1997 based on musculoskeletal, vascular, and neurologic impairment. Zelle et al.\textsuperscript{192} modified the group of neurologic impairment of this classification scheme and added the group with a complete brachial plexus avulsion as the most severe type (Table 37-1).

The diagnosis of scapulothoracic dissociation is based on history, clinical findings, and radiography. The difficulty for the treating physician is that the severe associated injuries may divert attention away from the sometimes subtle clinical signs of the scapulothoracic dissociation.\textsuperscript{94} The clinical signs may vary between swelling from a dissecting hematoma and a flail and pulseless extremity.

A well-centered chest radiograph will demonstrate lateral displacement of the scapula on the injured side, which is pathognomonic of a scapulothoracic dissociation. The degree of lateralization can be quantified using the scapula index (Fig. 37-10)\textsuperscript{86,134}

SURGICAL AND APPLIED ANATOMY AND COMMON SURGICAL APPROACHES

Surgical and Applied Anatomy
A thorough knowledge of the bony contours of the scapula and its related musculotendinous and neurovascular structures is
Kuhn's classification of fractures of the acromion process. Type I undisplaced: Ia avulsion fractures and Ib true fractures. Type II displaced without reduction of the subacromial space. Type III displaced with reduction of the subacromial space. This reduction may be by inferior displacement of the acromion or by an association with a superiorly displaced glenoid neck fracture.

required for adequate treatment of patients with scapular fractures, particularly if operative treatment is considered. The scapula is a large, flat, triangular bone that connects the clavicle to the humerus. At least 18 different muscles originate from and insert into this highly mobile bone (Fig. 37-11).

Special attention should be given to neurovascular structures at risk when surgery (both anteriorly and posteriorly) is undertaken.

Brachial Plexus

The brachial plexus descends in the concavity of the medial two thirds of the clavicle, accompanies the axillary artery, and lies beneath the pectoralis minor muscle. The musculocutaneous nerve originates from the lateral cord and penetrates the conjoined tendon of biceps and coracobrachialis at a variable distance (average 5 cm) from the coracoid tip (Fig. 37-12).

Suprascapular Nerve

Beneath the trapezius and omohyoid muscle, the suprascapular nerve enters the supraspinous fossa under the transverse ligament (or suprascapular ligament). The nerve runs beneath the supraspinatus muscle and curves round the external corner of the spine of the scapula to the infraspinous fossa (Fig. 37-13). In the supraspinous fossa, it gives off two branches to the supraspinatus muscle, and in the infraspinous fossa, it gives off two branches to the infraspinatus muscle, besides some filaments to the shoulder joint and scapula.

The safe zone for avoiding suprascapular nerve injury during open surgical procedures requiring dissection of the posterior shoulder joint within 2.3 cm of the superior glenoid rim and within 1.4 cm of the posterior rim of the glenoid at the level of the base of the scapular spine (Fig. 37-13).157

Axillary Nerve

Before entering the quadrilateral space, the axillary nerve runs together with the circumflex humeral artery overlying the subscapular muscle. The axillary nerve divides in this space and sends a posterior branch to the teres minor muscle, together with a lateral brachial cutaneous nerve (see Fig. 37-13). An anterior branch runs from this space approximately 5 cm below the edge of the acromion as the nerve passes anteriorly to innervate the anterior two thirds of the muscle.

The innervation of the posterior part of the deltoïd is variable. In 70%, it is innervated by the posterior branch, in 27% by posterior and anterior branches, and 3% only by the anterior branch.172 One should therefore be careful when performing a deltoïd splitting approach in a posterior surgical approach.

The branch to the teres minor arises from the posterior branch of the axillary nerve immediately adjacent to the inferior aspect of the capsule at the level of the glenoid rim (see Fig. 37-13).6

Common Surgical Approaches

Posterior Approach

The most common surgical posterior approach to the scapula in the last decades was the one described by Judet.83 It is an extensive approach which involves dissection of the infraspinatus muscle from the infraspinous fossa with the risk of neurovascular damage (suprascapular nerve) and structural muscle damage. Nowadays, the advocated posterior approaches are less invasive, since no or minimal infraspinatus detachment is necessary when using the interval between the teres minor and infraspinatus muscle.16,36,82,128,129

For the posterior approach, the patient is placed in a prone or lateral decubitus position. As described by Ebraheim,36 a skin incision is utilized along the scapular spine and then a vertical extension at the lateral border of the scapula (a “reverse Judet” skin incision) (Fig. 37-14). This allows the surgeon to reflect the complete posterior deltoïd, if necessary, off the scapular spine. A medi ally-based fascia flap is raised to expose the scapular musculature. The interval between the infraspinatus and teres minor muscles is entered with the infraspinatus muscle retracted cranially and the teres minor muscle laterally. This avoids any injury to the suprascapular nerve supplying the infra-
FIGURE 37-8 The radiograph (A) and CT (B,C) scan of an 80-year-old woman with a posterocranial glenohumeral luxation with a symptomatic pseudarthrosis of an acromion fracture. D. The patient underwent a plate osteosynthesis with bone graft and a reversed shoulder prosthesis.

FIGURE 37-9 Ogawa’s classification of coracoid fractures. Type I is proximal to and type II is distal to the coracoclavicular ligaments.

TABLE 37-1 The Classification System for Scapulothoracic Dissociation as Proposed by Damschen et al.²⁹ and Modified by Zelle et al.¹⁹²

<table>
<thead>
<tr>
<th>Type</th>
<th>Clinical Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Musculoskeletal injury alone</td>
</tr>
<tr>
<td>IIa</td>
<td>Musculoskeletal injury with vascular injury</td>
</tr>
<tr>
<td>IIb</td>
<td>Musculoskeletal injury with incomplete neurologic impairment of the upper extremity</td>
</tr>
<tr>
<td>III</td>
<td>Musculoskeletal injury with complete neurologic impairment of the upper extremity and vascular injury</td>
</tr>
<tr>
<td>IV</td>
<td>Musculoskeletal injury with complete brachial plexus avulsion</td>
</tr>
</tbody>
</table>
FIGURE 37-10 The diagnosis of scapulothoracic dissociation can be made on a nonrotated AP radiograph by comparing the distance from the medial border of the scapula with the spinous processes between the affected (long arrow) and unaffected (short arrow) sides. Kelbel et al.\textsuperscript{86} created the scapula index and reported a normal value to be a ratio of 1.07 ± 0.04.\textsuperscript{184}

FIGURE 37-11 Muscle insertions onto the scapula. Anterior (A) and posterior (B) views.

FIGURE 37-12 The position of the brachial plexus in relation to the anterior surface of the scapula. The supraclavicular and axillary nerves are also shown.
spinatus muscle as well as to the axillary nerve supplying the teres minor muscle. The lateral border of the scapula and the glenoid joint are then displayed, with the possibility of open reduction and internal fixation of scapular neck fractures and posterior glenoid fractures (types Ib, II, IV, and possibly V) (see Fig. 37-14).

A disadvantage of the described approach is the release of the posterior deltoid muscle off the scapular spine. Alternatives are described by Wirth who described a posterior approach with splitting of the posterior deltoid in line with its fibers distally to the upper border of the teres minor. Splitting the deltoid muscle, however, endangers the integrity of the axillary nerve.
at the level of the dense connective tissue of the subdeltoid fascia. Furthermore, the intramuscular nerve branches can occasionally be damaged within the lateral deltoid compartment.

Finally, Brodsky et al.\textsuperscript{16} and Jerosch et al.\textsuperscript{82} claim excellent exposure with their described posterior subdeltoid approach to the posterior aspect of the glenohumeral joint and scapular neck (Fig. 37-15). After a vertical skin incision, the inferior border of the spinal part of the deltoid is identified and mobilized by blunt dissection. By abducting the free draped arm 60 to 90 degrees, it is easier to retract the mobilized deltoid muscle and enter the interval between the infraspinatus and teres minor muscle as described above, allowing access to the posterior aspect of the glenoid and lateral border of the scapular body. Care should be taken to avoid injury to the circumflex scapular artery, which lies directly medial to the insertion of the long head of triceps, and the axillary and suprascapular nerves.

**Anterior Approach**

The anterior approach is used for coracoid and type Ia glenoid fractures. It is performed in the beach chair position, with the
incision made in Langer’s lines over the coracoid process to the axillary fold. The deltopectoral groove is opened with the cephalic vein attached to the deltoid muscle. In the presence of an anterior glenoid rim (type la) fracture, the subscapularis tendon is dissected off the anterior glenohumeral capsule and turned back medially. The capsule is opened and a humeral retractor is inserted behind the posterior aspect of the glenoid to visualize the entire glenoid cavity. After reduction and internal fixation of the glenoid fracture, the capsule, which is usually not stretched by the injury, is closed without performing a capsular shift.

**Superior Approach**
A superior approach is indicated when a superior glenoid fragment (type III, type V glenoid fracture) or an anatomic neck fracture of the scapula is difficult to control or stabilize. This approach can be added to an anterior or posterior approach. It is performed in a beach chair position with the skin incision made midway between the scapular spine and clavicle, laterally over the edge of the acromion. The trapezius can then be split in the line of its fibers, taking care to protect the accessory nerve which runs from anterior to posterior. After identifying the supraspinal notch, the supraspinatus muscle can either be split or shifted to the anterior or posterior part of the supraspinatus fossa depending on whether access is required to the anterosuperior or posterosuperior aspect of the glenoid. Care should be taken to protect and avoid injury to the supraspinal nerve and vessels that lie medial to the coracoid process.

**CURRENT TREATMENT OPTIONS**

**Glenoid Fractures**
Glenoid fractures make up 10% of all scapular fractures. Only 10% of glenoid fractures are significantly displaced, meriting surgical consideration. The majority (90%) are minimally or undisplaced and should be treated nonoperatively. Fractures of the glenoid are commonly found in the middle aged, between 40 and 60 years, with a male prevalence, and result most often from high-energy direct trauma. They occur when the humeral head is driven with a substantial force against the glenoid fossa. This may be caused by a direct force on the shoulder or an axial force through the humerus. The direction of this axial force will predict the fracture pattern. The most common fracture type is the anterior chip fragment fracture (type Ia) which is often associated with an anterior shoulder dislocation.

Many authors have reported good early functional outcome in patients treated nonoperatively with intra-articular fractures without associated instability. Since the late 1980s, operative treatment of glenoid fractures has gained more attention. There is a current trend towards arthroscopic techniques of glenoid fracture treatment, particularly in Ideberg type I fractures.

**Ideberg Type I**
Fractures of the anterior or posterior margin of the glenoid (types Ia and Ib, respectively) may cause instability of the glenohumeral articulation. These fracture types are usually sustained during traumatic glenohumeral subluxation or dislocation. After injury, the continuity between capsule, labrum, and fracture fragment is usually maintained. Instability of the glenohumeral joint can be expected when the fragment is displaced more than 1 cm and if at least 25% of the glenoid cavity anteriorly or at least 33% of the glenoid cavity posteriorly is involved. Although debate exists among surgeons about the amount of displacement and the size of the fracture that is acceptable, it is accepted that rim fractures associated with persistent or recurrent instability should undergo open reduction and internal fixation. An axillary radiograph and CT scan will demonstrate whether the humeral head is centered exactly in the glenoid fossa or is displaced along with the fracture fragment. The latter is an indication for surgical treatment. The goal of surgery is to prevent morbidity secondary to glenohumeral instability or degenerative joint disease by accurate reduction of the articular surface. According to the literature of the last decade, open procedures can be replaced by arthroscopic fixation of fragments with promising results particularly in type I fractures; most authors reported restoration of glenohumeral stability and good functional results.

**Ideberg Type II**
Type II fractures occur when the force through the humeral head is directed somewhat inferiorly, with a fracture line running from the glenoid fossa to the lateral border of the scapula body as a result. The amount of articular displacement and the degree of comminution determines the need for open reduction and internal fixation. Advocates of open reduction and internal fixation with displacement of more than 5 mm. This is based on the findings of and who demonstrated that the maximum thickness of glenoid articular cartilage is 5 mm. reviewed 22 patients with displaced glenoid fractures after a mean review period of 10 years: 9 had a type 2 fracture and were treated by open reduction and internal fixation through a posterior approach. He found a mean constant score of 94.

**Ideberg Type III**
A type III glenoid fossa fracture occurs when the force is directed superiorly, causing a fracture that involves the upper third of the glenoid fossa including the coracoid. The fracture runs from the glenoid fossa through the superior scapular body in the proximity of the scapular notch. According to and type III, V, and VI injuries in particular are prone to neurovascular injuries and damage to the SSSC. As with all other glenoid fractures, a type III injury is usually undisplaced and can be treated conservatively with good functional outcome in absence of associated neurologic injury. The indication for operative treatment is also displacement of more than 5 mm.

**Ideberg Type IV**
This type is caused by the humeral head being driven centrally into the glenoid fossa. A fracture line runs from the fossa directly across the scapula body to exit along its medial border and splits the glenoid fossa into two parts. Surgery is indicated when there is more than a 5 mm separation between the two parts. Surgery may prevent symptomatic degenerative joint disease, instability of the glenohumeral joint and, although extremely rare, nonunion of the fracture.

**Ideberg Type V**
Originally, described type V as a combination of a type II and IV injury, with a direct violent trauma as the mecha-
nism of trauma in most cases. Goss subdivided type 5 into three different subtypes (see Fig. 37-4). Type Va is a combination of type II and IV, Type Vb a combination of type III and IV, and type Vc a combination of type II, III, and IV. These subtypes are caused by more complex and probably greater forces than those causing the simpler fracture patterns. The same indications used for type II, III, and IV should be applied when determining the need for open reduction. Operative treatment of type V injuries does not uniformly lead to a good functional outcome which is probably mostly related to associated neurovascular injuries and postoperative complications.

Ideberg/Goss Type VI
Type VI fractures, introduced by Goss, are caused by the most violent force and include all fractures with at least two articular fragments. Even if displacement of the fragments is substantial, with or without subluxation of the humeral head, open reduction and internal fixation is not indicated due to the extensive comminution. In general, Ideberg's experience with fracture type II through V indicates:

1. Closed reduction under anesthesia is unsuccessful in improving position of the fracture fragment(s)
2. Secondary improvement of position of fracture fragments is possible after conservative treatment due to moulding of the fracture by muscle forces across the glenohumeral joint
3. A good result occurred in 75% of the cases after early mobilization
4. Open reduction and internal fixation may also lead to a good result in the absence of other significant ipsilateral shoulder fractures, nerve, or muscle injuries

Scapular Neck Fracture
A fracture of the neck of the scapula is the second most common scapular fracture. The suggested mechanisms of trauma are a direct blow to the shoulder, a fall on the point of the shoulder, or a fall on the outstretched arm. The fracture line most often extends from the suprascapular notch area across the neck of the scapula to its lateral border inferior to the glenoid (surgical neck fracture) or, rarely, lateral from the origin of the coracoid to its lateral border inferior to the glenoid (anatomic neck).

Scapular neck fractures, by definition extra-articular fractures, are sometimes accompanied by a fracture line through the coracoid process or may remain as an intact unit. If the scapular neck fracture is not associated with an ipsilateral shoulder lesion (of the SSSC), displacement is possible but rare. According to the concept of the SSSC, isolated fractures of the scapular neck are considered stable fractures.

The treatment of these fractures has historically been nonoperative, mostly with a favorable outcome. Recommended methods of closed treatment include closed reduction and olecranon pin traction for 3 weeks followed by a sling, closed reduction and a shoulder spica cast for 6 to 8 weeks, and even the use of a traction suspension system for reduction of a displaced neck fracture. Some authors doubt the usefulness of closed reduction in these fractures, advocating the use of a sling and suggest mobilizing the affected arm as soon as possible. Lindholm and Leven studied a series of scapular neck and body fractures and concluded that if untreated, all fractures healed in the position displayed at the time of the original injury.

These studies, however, do not present data to justify these recommendations. A more differentiated approach is necessary as conservative treatment does not uniformly lead to a good result. Several authors noted fair to poor results after conservative treatment of severely displaced scapular neck fractures. Displacement is defined as at least 1 cm of translation or 40 degrees of angulation (or a glenopolar angle [GPA] < 20 degrees) in the AP plane of the scapula and separates minor from major injuries according to Zdravkovic, Nordqvist and Petersson, and Geel.

Ada and Millar reported on 24 patients with displaced scapular neck fractures. Of the 16 patients treated conservatively, 50% complained of pain at night, 40% had weakness of abduction, and 20% had decreased range of motion. Whether translational displacement of at least 1 cm remains a good criterion for surgical treatment of scapular neck fractures is controversial. The criterion of angulation greater than or equal to 40 degrees (or a GPA < 20 degrees) is probably less questionable. Several authors reported less favorable long-term outcome after conservative treatment of angulated scapular neck fractures, compared with scapular neck fractures without angular displacement. Good to excellent results have been reported on open reduction and internal fixation of patients with displaced scapular neck fractures. In these series, however, displaced scapular neck fractures are in most cases associated with ipsilateral clavicle fractures. According to Zlowodzki, who performed a systematic review of 520 scapular fractures in 22 case series, excellent or good results can be achieved with nonoperative treatment of isolated neck fractures in 77% of the cases and in 88% of the cases with operative treatment. Universal guidelines for conservative or operative treatment are difficult to establish empirically because the available literature does not include randomized or nonrandomized comparative studies. Treatment should, therefore, be individualized.

The Superior Shoulder Suspensory Complex
Goss described the SSSC, consisting of the glenoid, coracoid, acromion, distal clavicle, coracoclavicular ligaments, and acromioclavicular ligaments. This bone–soft tissue ring maintains the normal, stable relationship between the upper extremity and the axial skeleton. Single disruptions of the SSSC, such as an isolated scapular neck fracture, are usually anatomically stable because the integrity of the complex is preserved, and nonoperative management yields good functional results. When the complex is disrupted in two places (double disruption), such as a scapular neck fracture with an acromioclavicular joint disruption, a potentially unstable anatomic situation is created. Because the SSSC includes the glenoid, acromion, and coracoid, many double disruption injuries involve the scapula. In the presence of a displaced fracture of the acromion, coracoid process, glenoid, or scapular neck, the possibility of another lesion of the SSSC (i.e., a double disruption) should be considered. According to Goss, open reduction is indicated for double disruptions that are accompanied by significant displacement, which may lead to delayed union, malunion, or nonunion as well as long-term functional deficits.
The most common described double disruption of the SSSC is the ipsilateral glenoid surgical neck and midshaft clavicle fracture. This injury, although the terminology is criticized, is also defined as a floating shoulder.

The Floating Shoulder

Ganz and Noesberger were the first authors who described this injury in 1975. They suggested a loss of the stabilizing effect of the clavicle in the case of a combination of these two fractures. In contrast to isolated scapular fractures, they found more severe displacement of the scapular fracture when combined with an ipsilateral clavicle fracture. The weight of the arm and the combined contraction of the biceps, triceps, and coracobrachialis muscles may cause inferior and rotational displacement of the distal fragment resulting in a change in the contour of the affected shoulder, the so-called drooping shoulder (Fig. 37-17). Apart from this possible caudal and rotational displacement, it is also suggested, although criticized by some, that the glenoid fragment is displaced anteromedially by contraction of the rotator cuff muscles (Fig. 37-18). Translational displacement of the scapular neck will result in shortening of the lever arm of the rotator cuff musculature and threaten the functional balance of the glenohumeral joint. This may result in loss of abduction strength, although this is not necessarily synonymous with limitation of range of motion, as demonstrated in a biomechanical analysis. Williams and colleagues conducted the only cadaver study on this subject to determine the stability afforded by specific structures. They concluded that ipsilateral fractures of the scapular neck and the shaft of the clavicle do not produce a floating shoulder without additional disruption of the coracoclavicular and acromiocavicular capsular ligaments. These findings have not yet been confirmed in clinical studies.

The rarity of the floating shoulder is also illustrated by the complete lack of well-performed, prospective studies with comparison of different treatment options. The literature on this subject is limited to data provided only by case reports and retrospective studies of small patient series.

Good clinical results are reported for both conservative and operative treatment (Table 37-2). Traditionally, floating shoulders were treated nonoperatively. However, over the last two decades, there has been increased interest in open reduction and internal fixation of these fractures.


![FIGURE 37-17 Drooping aspect of the left shoulder.](image)
covic\textsuperscript{71} reported on 9 patients: 7 had been treated operatively (with osteosynthesis only of the clavicle) and the remaining 2 had been treated nonoperatively. Their good results led them to recommend open reduction and internal fixation of the clavicle only, in order to prevent malunion of the scapular neck. The authors presumed that the glenoid neck fracture would usually reduce and be stabilized indirectly. Rikli\textsuperscript{141} retrospectively analyzed 12 cases, 11 with osteosynthesis of the clavicle alone, whereas one had both the clavicle and the glenoid neck fractures fixed. The findings of Leung and Lam\textsuperscript{99} are based on the treatment results in 15 cases in whom simultaneous fixation of the displaced scapular and clavicle fractures had been performed. All but one patient had a good, or excellent, functional result, according to the scoring system of Rowe\textsuperscript{151}. All fractures healed at an average of 8 weeks postoperatively. Good results in 7 operatively treated patients, by fixation of both the scapular neck and clavicle fractures, or disrupted acromioclavicular joint, have also been described in a retrospective study by Egol et al.\textsuperscript{119}

### Table 37-2

**Reported Results of Conservative and Operative Management of the Floating Shoulder**

<table>
<thead>
<tr>
<th>Study</th>
<th>Number</th>
<th>Conservative</th>
<th>ORIF Clavicle</th>
<th>ORIF Clavicle and Scapula</th>
<th>Outcome Measure</th>
<th>Outcome Conservative (mean score)</th>
<th>Outcome Operative (mean score)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edwards\textsuperscript{59}</td>
<td>20</td>
<td>20</td>
<td>—</td>
<td>—</td>
<td>Constant\textsuperscript{28}</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>Egol\textsuperscript{40}</td>
<td>19</td>
<td>12</td>
<td>—</td>
<td>7</td>
<td>American Shoulder and Elbow Surgeons\textsuperscript{119}</td>
<td>80.2</td>
<td>88.7</td>
</tr>
<tr>
<td>Hashiguchi\textsuperscript{69}</td>
<td>5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>University of California, Los Angeles\textsuperscript{41}</td>
<td>34.2</td>
<td></td>
</tr>
<tr>
<td>Herscovici\textsuperscript{71}</td>
<td>9</td>
<td>2</td>
<td>—</td>
<td>7</td>
<td>Herscovici 1 good; 1 poor</td>
<td>7 excellent</td>
<td></td>
</tr>
<tr>
<td>Labler\textsuperscript{93}</td>
<td>17</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td>Constant\textsuperscript{28}</td>
<td>90</td>
<td>66 93 (ORIF both)</td>
</tr>
<tr>
<td>Leung\textsuperscript{99}</td>
<td>15</td>
<td>—</td>
<td>—</td>
<td>15</td>
<td>Rowe\textsuperscript{151}</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Ramos\textsuperscript{139}</td>
<td>13</td>
<td>13</td>
<td>—</td>
<td>—</td>
<td>Herscovici\textsuperscript{71} 11 excellent; 1 good</td>
<td>76</td>
<td>Constant: 71%</td>
</tr>
<tr>
<td>Rikli\textsuperscript{141}</td>
<td>12</td>
<td>—</td>
<td>11</td>
<td>1</td>
<td>Constant\textsuperscript{28}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>van Noort\textsuperscript{175}</td>
<td>35</td>
<td>28</td>
<td>7</td>
<td></td>
<td>Constant\textsuperscript{28}</td>
<td>76</td>
<td>Constant: 76%</td>
</tr>
</tbody>
</table>

ORIF, open reduction and internal fixation.
al.40 Finally, in a study of Labler et al.,63 6 patients were treated with internal fixation of only the clavicle and 3 with fixation of both clavicle and scapular fractures.

Routine operative treatment of a floating shoulder without regard to displacement has recently been questioned. Edwards49 reported excellent results in 17 and good results in 3 patients in whom all ipsilateral fractures of the scapula and clavicle had been treated nonoperatively by a shoulder immobilizer, until the associated injuries allowed mobilization of the shoulder. They recommend conservative treatment, especially in patients with less than 5 mm displacement. In a retrospective study, van Noort et al.127 reported fair to good results in 28 patients treated conservatively (mean constant score: 76), with a well-aligned glenoid. The authors concluded that these rare shoulder lesions are not unstable by definition and that conservative treatment leads to a good functional outcome in the absence of caudal displacement of the glenoid. Caudal displacement was defined as an inferior angulation of the glenoid of at least 20 degrees.174 Ramos et al.139 in 1997 reviewed 13 patients with ipsilateral fracture of the clavicle and scapular neck treated conservatively. The average follow-up was 7.5 years. Using Herscovici's scoring method,71 they reported 84.6% excellent, 7.7% good, and 7.7% fair results.

Based on both clinical and biomechanical studies, it remains unclear under which criteria a floating shoulder should be treated operatively. Current experience indicates that an undisplaced, or minimally displaced, ipsilateral clavicle and scapular neck fracture can be treated conservatively, with a good functional outcome. The amount of displacement that is acceptable at the fracture sites of the glenoid neck and clavicle is controversial.

Scapular Body Fracture

Approximately 50% of scapular fractures involve the scapular body and spine.61 This fracture type is correlated with the highest incidence of associated injuries.19,169 They are generally caused by indirect forces or by direct trauma. Wyrsch and co-workers190 reported a scapular body fracture in a professional boxer who sustained the injury during an attempted punch. More rare causes are seizures, electrical shock treatments,11,70,110,156 or stress fractures.136 Scapular body fractures heal readily and do not merit operative intervention.115,116,184 regardless of the number of fracture fragments. The fact that these fractures heal well without significant clinical symptoms is probably directly related to the protection of a thick layer of muscles surrounding the scapula. Several series of conservatively treated patients with scapular body fractures have been reported with union of the fracture and a good functional outcome.3,79,103,157 Złowodzki194 reported in a systematic review of 520 scapular fractures in 22 case series, that 99% of all scapular body fractures had been treated nonoperatively. Excellent or good results were achieved with nonoperative treatment in 88% of the cases.

Nonetheless, painful scapulothoracic crepitus caused by malunion of the scapular body may have adverse mechanical and functional effects on shoulder movement. Excision of the bony prominence in these cases is usually curative.44,47 Other clinical symptoms are pain, limited range of motion, and winging of the scapula by loss of the serratus anterior muscle.56 Nordqvist and Petersson127 found poor long-term results in some patients with more than 10 mm of displacement. Nonunions are extremely rare. Two cases have been reported which were both treated successfully by open reduction, rigid internal fixation, and bone grafting.43,64

Acromial Fracture

The acromion provides one side of the acromioclavicular joint and serves as the point of attachment for the deltoid muscle and a number of ligaments. By forming the roof of the glenohumeral joint, it lends posterosuperior stability. Approximately 8% to 9% of all scapular fractures involve the acromion.3,115,184

There are four causes described for an acromial fracture:
1. A direct blow from the outside, in general a significant force.
2. A force transmitted via the humeral head from the inside. Traumatic superior displacement of the humeral head, which may also result in an associated rotator cuff tear, can cause an (superiorly displaced) acromial fracture. Another mechanism is rotator cuff arthropathy, in which an acromial fracture may occur by superior migration of the humeral head.20
3. An avulsion fracture is usually caused by an indirect force. Heyse-Moore and Stoker,72 Rask and Steinbergh,1,40 and Russo et al.153 reported forceful contraction of the deltoid muscle resulting in an avulsion fracture of the acromion.
4. Stress fractures of the acromion have been reported, particularly in sports.65,178,181 Subacromial decompression with significant thinning of the acromion may also lead to a stress fracture.106,111,152,182

A diversity of associated ipsilateral shoulder lesions with an acromion fracture is described. The brachial plexus is at risk particularly with an inferiorly displaced acromion fracture.114,123 Other associated lesions, as reported earlier, are rotator cuff lesions.104,145 Finally, ipsilateral acromioclavicular joint lesions, coracoid, clavicle, glenoid, and proximal humeral fractures and shoulder dislocations have been reported.58,92,95,102,114,122,193

Independent of the mechanism of trauma, when a fracture does occur, it is usually non- or minimally displaced. Nonoperative treatment in these cases will lead to union of the fracture with a good to excellent functional outcome.61 Most acromion fractures are successfully treated simply by immobilization with a sling or Velpeau dressing until the pain has subsided, which is usually within 3 weeks.1,81,90,92,102,114,120 Some authors have advocated the use of a spica cast with the shoulder in abduction.122,184 Omission of a sling or another form of immobilization may cause secondary displacement of the fracture.59

According to the classification of Kuhn,90 the group of non- or minimally displaced fractures are type I fractures and caused by indirect force (avulsion fracture-type Ia) or a direct trauma (type Ib). Nonoperative treatment is also advocated by Kuhn90 in dislocated acromial fractures in which the subacromial space is not compromised (type II fracture). However, a poor clinical outcome or a symptomatic pseudarthrosis of patients with a type II fracture has been reported.3,49 In type III displaced fractures in which the subacromial space is diminished by the inferior pull of the deltoid on the acromial fragment, open reduction with internal fixation is advocated by Kuhn90 and Ogawa132 to prevent secondary impingement. Most authors recommend open reduction and internal fixation for markedly dis-
placed acromion fractures to reduce the acromioclavicular joint and prevent nonunion, malunion, and secondary impingement. When surgery is performed, a variety of surgical techniques may be employed, including the use of tension band wiring, sutures, Kirschner-wires, staples, lag screws, and plates. Excision of the acromial fragment has been reported but is generally not recommended for fragments larger than half an inch because it can result in substantial weakness of the deltoid muscle.

### Coracoid Fracture

The most common mechanisms that have been described as a cause of a coracoid fracture are:

1. A direct blow to the superior point of the shoulder
2. A direct contact between the humeral head and coracoid process in case of an anterior shoulder dislocation
3. An avulsion fracture by a forceful contraction of the short head of the biceps, pectoralis minor, or coracobrachialis muscle
4. As part of an acromioclavicular dislocation
5. Stress fractures have been reported: medial migration of the humeral head from rotator cuff arthropathy may result in a coracoid fracture

Coracoid fractures may be isolated, but in many cases are accompanied by ipsilateral shoulder injuries. Ogawa reported acromioclavicular dislocations as the most common associated lesion, seen in 60 of the 67 described patients. Other common associated lesions are lacerations or abrasions over the posterolateral or lateral deltoid muscle, (lateral) clavicle fractures, shoulder dislocations, rotator cuff tears.

Fractures in adults are most common at the base of the coracoid, whether or not with extension in the upper border of the scapula and/or the glenoid. Other reported sites are the middle portion and the tip.

Many methods of treatment of coracoid fractures have been described. There is, however, no consensus in the literature about the preferred treatment of coracoid fractures. Many authors suggest that non- or minimally displaced fractures can be successfully treated by conservative treatment. On occasion, however, these injuries may be significantly displaced and of functional importance, thus making surgical management a consideration. Fractures of the coracoid tip are avulsion injuries (Ogawa type 2) which may displace considerably. Despite the chance of nonunion, this type of fracture can be treated conservatively with good functional outcome. On occasion, operative treatment is indicated when the fractured coracoid tip impedes the reduction of an anterior dislocated humeral head. Other indications for surgery include a painful nonunion after anterior shoulder dislocation.

Treatment of fractures of the coracoid base (type 1) follow the same reasoning described for fractures of the coracoid tip. However, displacement of the fracture is more common which may be due to accompanying ipsilateral shoulder injuries (double disruptions of the SSSC). In these circumstances, or in cases with extension of the fracture into the glenoid fossa (with displacement), open reduction and internal fixation with screw fixation of the coracoid fracture is advocated. Martin-Herrero, however, described satisfactory outcome in conservative treatment in 7 patients despite displacement of the fracture and associated ipsilateral shoulder injuries in 6.

### Scapulothoracic Dissociation

Scapulothoracic dissociation is characterized by a complete loss of scapulothoracic articulation and lateral displacement of the scapula, while the skin is usually intact. It is classically caused by a violent lateral distraction or rotational displacement of the shoulder girdle when the upper extremity is caught on a fixed object while the body is moving at high speed. It is a rare, severe injury of the shoulder girdle with a high mortality rate. Some authors describe this injury, which is almost always accompanied by severe vascular injuries (prevalence 88%–100%), as an internal forequarter amputation. When surgery is performed, a variety of surgical stabilization and resuscitation being of paramount importance. Treatment recommendations have focused on the care of the accompanying neurovascular injury. In a hemodynamically stable patient, arteriography is used to determine the vascular integrity, followed by surgical repair if necessary. However, it should be appreciated that an extensive collateral network around the shoulder can protect against limb-threatening ischemia. Sampson et al. presented a series of 11 cases. They questioned the need for vascular repair in these patients, all of whom had a complete brachial plexus palsy, no radial pulse, and subclavian or axillary artery occlusion on arteriography. Of these 11 cases, 6 were revascularized and 5 were not. All 11 limbs remained viable, although none of the 11 patients regained any function. Zelle et al. demonstrated that the extent of the neurologic injury is of paramount importance in predicting the functional outcome. All of their patients with a complete brachial plexus avulsion either had an amputation or had poor shoulder function at the time of follow-up. Partial plexus injuries, however, have a good prognosis, and most patients achieve complete recovery or regain functional use of the extremity. If upper extremity function is not restorable, an immediate above-elbow amputation seems to result in better functional outcomes, lower complication rates, better relief of causalgia, and more successful return to work than a late amputation.

The management of patients with scapulothoracic dissociation should follow the ATLS principles with cardiopulmonary stabilization and resuscitation being of paramount importance. The recommended treatment of associated osseous lesions in patients with scapulothoracic dissociation is unclear and should therefore be individualized. Nevertheless, advised open reduction and internal fixation of clavicle fractures and stabilisation of disrupted acromioclavicular or sternoclavicular joints for three reasons: to avoid delayed or nonunion, to restore as much stability as possible to the shoulder complex thus reducing long-term functional problems, and to protect the brachial...
plexus, subclavian, and axillary vessels from further injury caused by tensile forces.

**AUTHOR’S PREFERRED TREATMENT**

**Scapular Neck Fractures**

Reduction of translational displacement (>1 cm) in an isolated scapular neck fracture is not necessary to obtain a good functional outcome with conservative treatment. One should be aware of the possibility of ipsilateral shoulder lesions (e.g., fractures, rotator cuff lesions, and intra-articular glenohumeral damage), which may influence the final functional outcome. Symptomatic local care in a shoulder immobilizer followed by passive exercises as soon as the pain allows will not interfere with fracture healing and will result in a good to excellent functional outcome.

In case of an associated ipsilateral clavicle fracture (floating shoulder), there is a chance of further displacement of either or both of the fractures. Current experience indicates that undisplaced, or minimally displaced, ipsilateral clavicle and scapular neck fractures can be treated conservatively with a good functional outcome. In relatively young patients without comorbidities, open reduction and internal fixation by plate osteosynthesis should be considered in displaced, shortened, midshaft clavicle fractures because of the chance of nonunion (prevalence 15%) or malunion. Fixation of the clavicle fracture may allow reduction of the glenoid neck fracture and restoration of the shoulder contour. However, despite anatomic reduction of the clavicle fracture, displacement of the scapular neck fracture may persist. In particular, rotational displacement of the scapular neck will compromise the functional outcome. In case of caudal angulation of the glenoid fossa of more than 20 degrees (or a GPA angle >30 degrees) (see Fig. 37-6), operative treatment should be considered through a posterior approach with plate osteosynthesis along the lateral border of the scapula (Fig. 37-19). However, caution should be employed to avoid surgical overtreatment in the absence of data to support an aggressive approach.

**Glenoid Fossa Fractures**

For type Ia fractures, surgical treatment is preferred where there is subluxation of the humeral head or in fractures likely to cause glenohumeral instability, which can be predicted if the fracture is displaced more than 5 mm or if a quarter or more of the glenoid cavity is involved. Exposure is performed through a standard deltopectoral approach with mobilization of the subscapularis muscle. A large fragment can be fixed with two screws, but smaller or comminuted fragments may require a buttress plate with smaller screws.

The same indications for surgery as for a type Ia fracture should be applied for a type Ib fracture except that the size of the posterior fragment which will predict instability is a third or more of the glenoid cavity. For posterior fractures, a posterior glenohumeral exposure is advocated with access to the glenohumeral joint through the interval between the infraspinatus and teres minor muscles. In both types Ia and Ib, there are possible advantages of arthroscopically controlled operative treatment using percutaneous screw fixation. This is typically dependable on the skill of the surgeon but also on the size and comminution of the fracture fragment.

Types II through V have poorly defined indications for operative treatment. However, on the basis of available reports, it seems reasonable to conclude that surgery has a definite role in the treatment of glenoid fossa fractures. When the humeral head is not centered in the major portion of the glenoid fossa and is subluxed along with the fracture fragment, open reduction and internal fixation of the fracture is indicated. Type II fractures are approached posteriorly, and type III by either a superior or combined posterior and superior approach. A cannulated interfragmentary compression screw (3.5 mm) is placed after a Krischner-wire positioned in the superior fragment is used to manipulate and reduce the fracture. A posterosuperior approach is usually required for the treatment of types III, IV, Vb, and Vc, so that the superior glenoid fragment can be reduced and fixed relative to the inferior aspect of the glenoid cavity. Care should be taken when using the posterosuperior approach which places the suprascapular nerve in some jeopardy as the nerve passes through the scapular notch, the supraspinatus muscle, the spinoglenoid notch, and the infraspinatus muscle.

Type VI fractures are managed nonoperatively. Passive exercises should be started as soon as possible in order to prevent the development of a stiff painful shoulder. These injuries have the highest chance of posttraumatic arthritis.

**COMPLICATIONS**

The available information with regard to the complications of scapular fractures and their treatment is very sparse. One should

![FIGURE 37-19 A scapular neck fracture which has been reduced and stabilized with a plate.](image)
make a distinction between the complications of treatment and concomitant injuries of scapular fractures. The latter are sometimes life-threatening and may have more consequences with respect to the priorities of treatment and the overall functional outcome. On the other hand, regional complications such as nerve injuries may influence the functional outcome of the affected shoulder dramatically. An example is a brachial plexus injury, which is described by Rockwood,\(^{143}\) after coracoid fracture. Suprascalpular nerve injuries are reported following scapular neck fracture with extension into the suprascapular notch.\(^{137,160}\) and from coracoid base fractures.\(^{143}\) Axillary nerve and brachial plexus injuries have been described in association with an acromion fracture.\(^{114,115}\)

Reported complications after conservative treatment are in general uncommon and variable. Malunion and particularly nonunion of scapula fractures are very rare. In a recent search of the medical literature, Marek\(^{107}\) discovered only 15 cases of scapula nonunion after nonoperative management. Malunion of particularly scapular body fractures is well tolerated, although painful scapulothoracic crepitus is described.\(^{1,3,127}\) Displaced glenoid fractures may lead to glenohumeral arthritis and instability.\(^{1,66}\) pain (in rest and with exertion), limitation in range of motion, and weakness.\(^{1,3,127,101}\) Some authors suggest that displaced fractures of the glenoid neck can lead to altered mechanics of the surrounding soft tissues, giving rise to glenohumeral pain and dysfunction.\(^{1,3,49,127,135,146}\)

With regard to complications of operatively treated patients with scapular fractures, Lantry\(^{97}\) analyzed the postoperative complications of 212 cases described in 15 retrospective case series. The overall reported complication rate in these studies was fairly low. The most common complications were removal of implants in 7 % due to metal failure or local discomfort and infection in 4 %. Other mentioned complications were nerve injuries (2%), mostly involving the suprascalpular nerve (4 out of 5), reoperation other than hardware removal for posttraumatic arthritis (2%), rotator cuff dysfunction (1%), and heterotopic ossification (1%). Nonunion after operatively treated scapular fractures is not cited as a complication except for one reported case by Marek.\(^{107}\) Finally, an improper physical therapy rehabilitation program or a poor patient compliance may contribute to unnecessary postoperative shoulder stiffness.

**FUNCTIONAL OUTCOME**

In general, more than 90% of scapular fractures are non- or minimally displaced and do well clinically after conservative treatment.\(^{79,115,184}\) This observation has been based on treatment of scapular fractures in general, and its relevance is therefore very limited. A more differentiated approach turned out to be necessary as conservative treatment does not uniformly lead to good results.\(^{1,9,135}\) Literature regarding outcome of treatment of specific fracture types, however, is mostly comprised of case reports and small series and is therefore scarce. There is particularly concern about poor functional outcome after conservative treatment of displaced acromion, coracoid process (base), scapular neck, and glenoid fossa fractures.\(^{1,3,49,127,135,146}\) With respect to functional outcome after operative treatment, most series concern glenoid fossa fractures\(^{57,66,84,98,112,156}\) and scapular neck fractures with or without an ipsilateral clavicle fracture.\(^{1,8,40,66,69,71,93,99,141,173}\) In a systematic review of 243 cases, Lantry\(^{97}\) pointed out that good to excellent functional results were obtained in approximately 85% of cases which mainly consisted of displaced glenoid fossa and scapular neck fractures. Limitations of interpreting these study results are the retrospective character of the case series (level IV) and the various outcome scales and scoring systems. In the above mentioned studies, the following shoulder scoring systems were used: American Shoulder and Elbow Surgeons,\(^{40}\) constant score,\(^{8,9,30,93,141,156,173,176}\) Herscovici score,\(^{30,71,130}\) Neer score,\(^{131,133}\) Rowe score,\(^{98,99}\) University of California, Los Angeles, score,\(^{69}\) or subjective scores based on the surgeon’s assessment mainly based on pain and range of motion.\(^{1,3,66,112,116,127}\)

**REFERENCES**

20 Upper Extremity


AUTHOR QUERIES
AQ1—Please confirm this cross reference.
AQ2—This reference was not called out in the text. Please provide call out.